Order this document by MC3359/D

MOTOROLA

MC3359

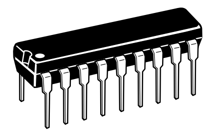
Low Power Narrowband FM IF

HIGH GAIN LOW POWER FM IF

SEMICONDUCTOR TECHNICAL DATA

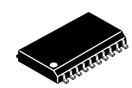
. . . includes oscillator, mixer, limiting amplifier, AFC, quadrature discriminator, op/amp, squelch, scan control, and mute switch. The MC3359 is designed to detect narrowband FM signals using a 455 kHz ceramic filter for use in FM dual conversion communications equipment. The MC3359 is similar to the MC3357 except that the MC3359 has an additional limiting IF stage, an AFC output, and an opposite polarity Broadcast Detector. The MC3359 also requires fewer external parts. For low cost applications requiring V_{CC} below 6.0 V, the MC3361BP,BD are recommended. For applications requiring a fixed, tuned, ceramic quadrature resonator, use the MC3357. For applications requiring dual conversion and RSSI, refer to these devices; MC3335, MC3362 and MC3363.

- Low Drain Current: 3.6 mA (Typical) @ V_{CC} = 6.0 Vdc
- Excellent Sensitivity: Input Limiting Voltage – – 3.0 dB = 2.0 µV (Typical)
- Low Number of External Parts Required
- For Low Voltage and RSSI, use the MC3371



P SUFFIX
PLASTIC PACKAGE
CASE 707

DW SUFFIX
PLASTIC PACKAGE
CASE 751D
(SO–20L)



ORDERING INFORMATION

Device	Operating Temperature Range	Package
MC3359DW	T_A = –30 to +70°C	SO–20L
MC3359P		Plastic DIP

Figure 1. Simplified Application in a Scanner Receiver

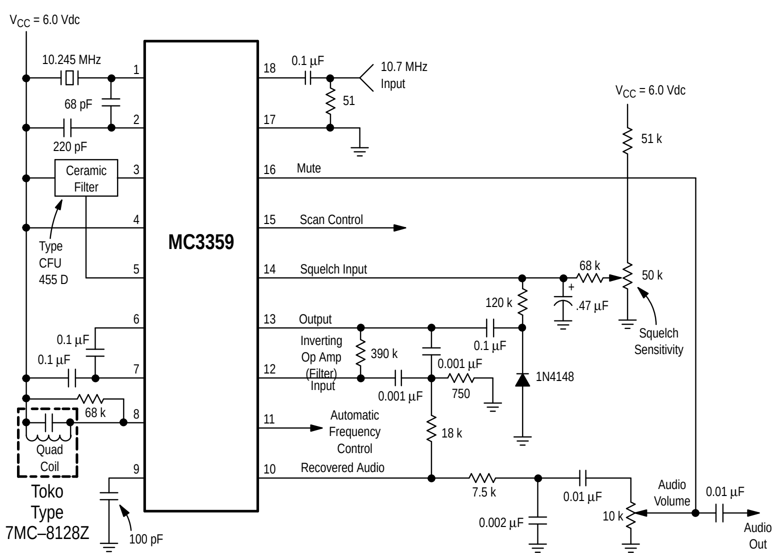
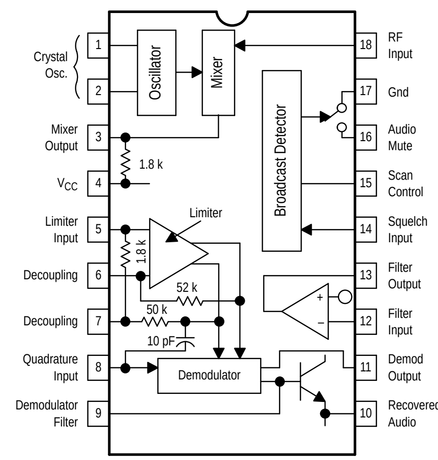
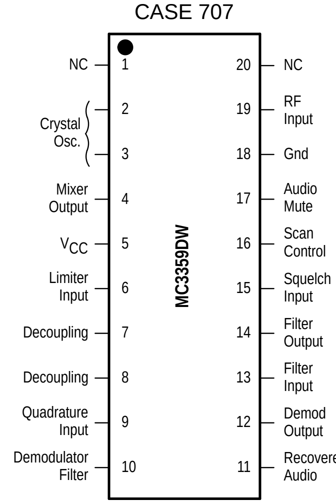


Figure 2. Pin Connections and Functional Block Diagram



CASE 707



CASE 751D

MAXIMUM RATINGS (T_A = 25°C, unless otherwise noted)

Rating	Pin	Symbol	Value	Unit
Power Supply Voltage	4	V_{CC}(max)	12	Vdc
Operating Supply Voltage Range	4	V_{CC}	6 to 9	Vdc
Input Voltage ($V_{CC} \geqslant$ 6.0 Volts)	18	V_{18}	1.0	V_{rms}
Mute Function	16	V_{16}	– 0.7 to 12	V_{pk}
Junction Temperature	–	T_J	150	°C
Operating Ambient Temperature Range	–	T_A	– 30 to + 70	°C
Storage Temperature Range	–	T_{stg}	– 65 to + 150	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 6.0 Vdc, f_o = 10.7 MHz, $\Delta f = \pm$ 3.0 kHz, f_{mod} = 1.0 kHz, 50 Ω source, T_A = 25°C test circuit of Figure 3, unless otherwise noted)

Characteristics		Min	Typ	Max	Units
Drain Current (Pins 4 and 8)	Squelch Off Squelch On	– –	3.6 5.4	6.0 7.0	mA
Input for 20 dB Quieting		–	8.0	–	µVrms
Input for – 3.0 dB Limiting		–	2.0	–	µVrms
Mixer Voltage Gain (Pin 18 to Pin 3, Open)		–	46	–	
Mixer Third Order Intercept, 50 Ω Input		–	– 1.0	–	dBm
Mixer Input Resistance		–	3.6	–	kΩ
Mixer Input Capacitance		–	2.2	–	pF
Recovered Audio, Pin 10 (Input Signal 1.0 mVrms)		450	700	–	mVrms
Detector Center Frequency Slope, Pin 10		–	0.3	–	V/kHz
AFC Center Slope, Pin 11, Unloaded		–	12	–	V/kHz
Filter Gain (test circuit of Figure 3)		40	51	–	dB
Squelch Threshold, Through 10K to Pin 14		–	0.62	–	Vdc
Scan Control Current, Pin 15	Pin 14 – High – Low	– 2.0	0.01 2.4	1.0 –	µA mA
Mute Switch Impedance Pin 16 to Ground	Pin 14 – High – Low	–	5.0 1.5	10 –	Ω MΩ

Figure 3. Test Circuit

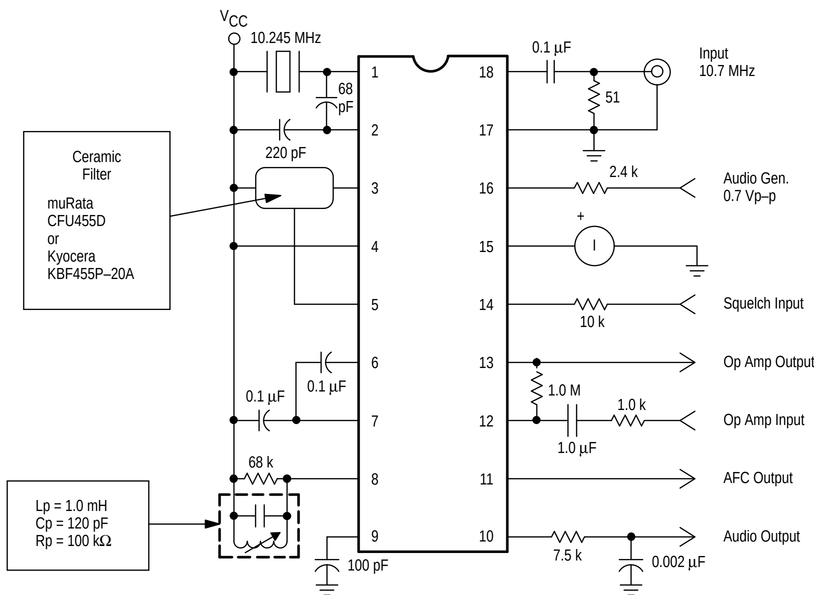


Figure 4. Mixer Voltage Gain

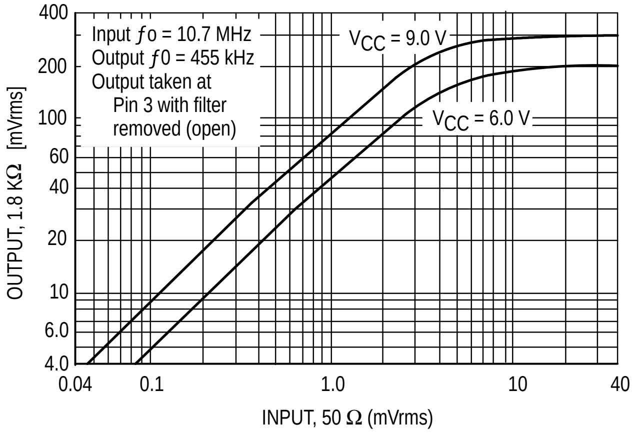


Figure 5. Limiting IF Frequency Response

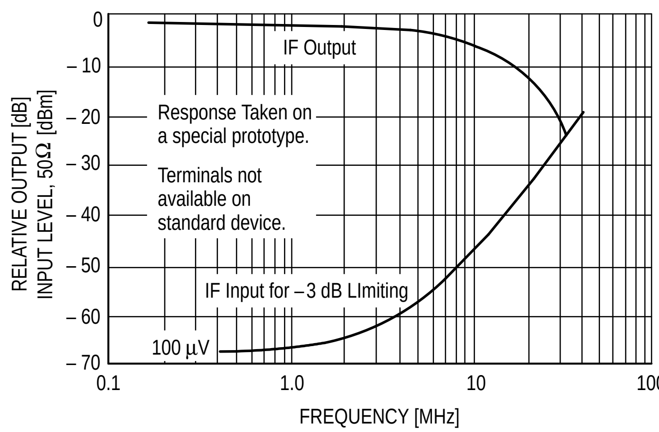


Figure 6. Mixer Third Order Intermodulation Performance

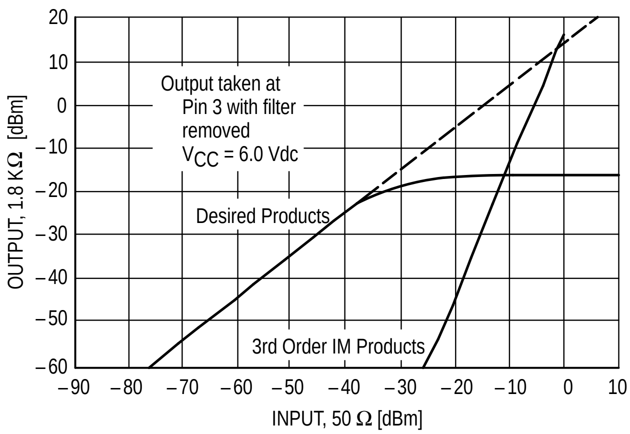


Figure 7. Detector and AFC Responses

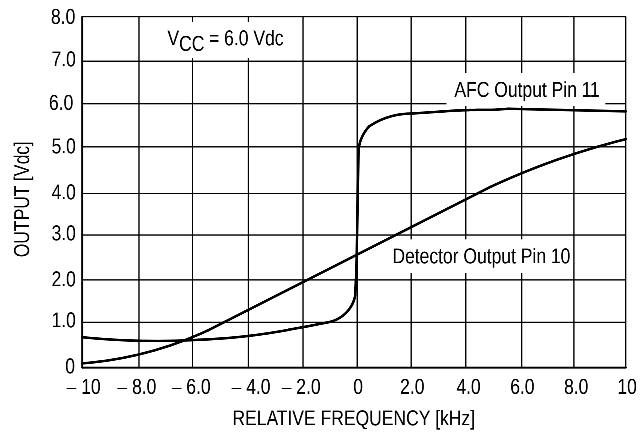


Figure 8. Relative Mixer Gain

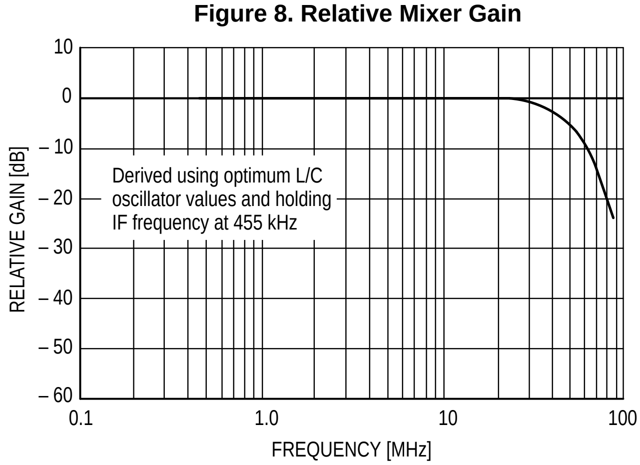


Figure 9. Overall Gain, Noise, and AM Rejection

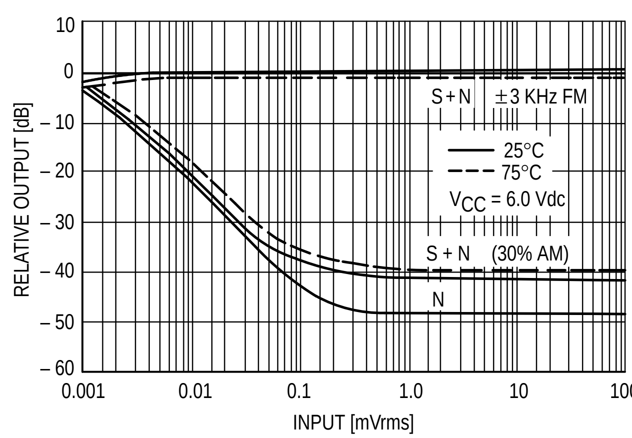


Figure 10. Output Components of Signal, Noise, and Distortion

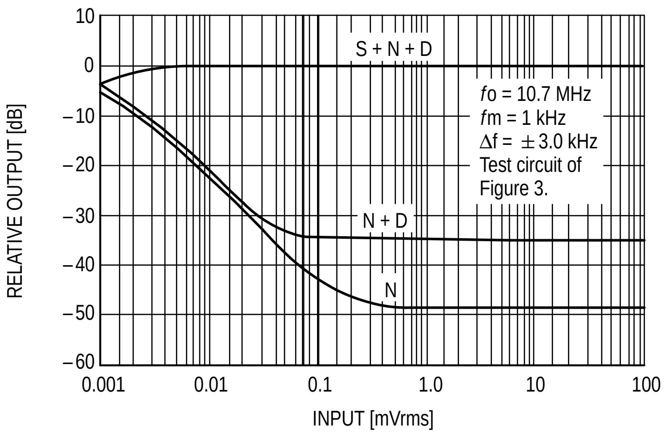


Figure 11. Audio Output and Total Current Drain versus Supply Voltage

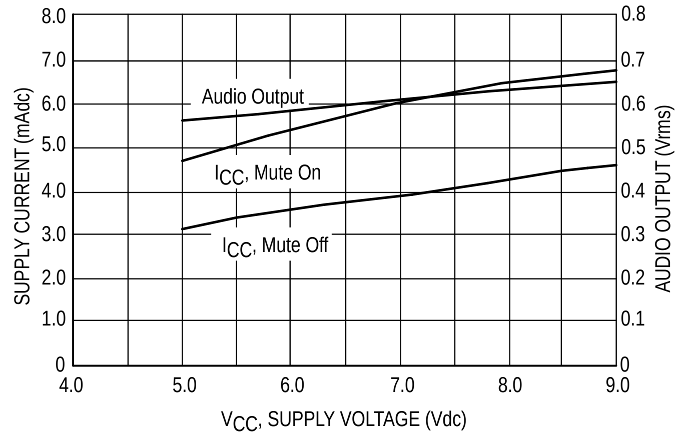


Figure 12. L/C Oscillator, Temperature and Power Supply Sensitivity

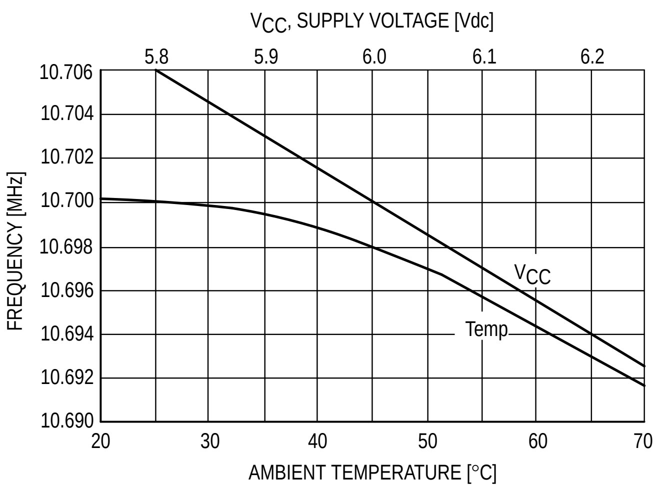


Figure 13. Op Amp Gain and Phase Response

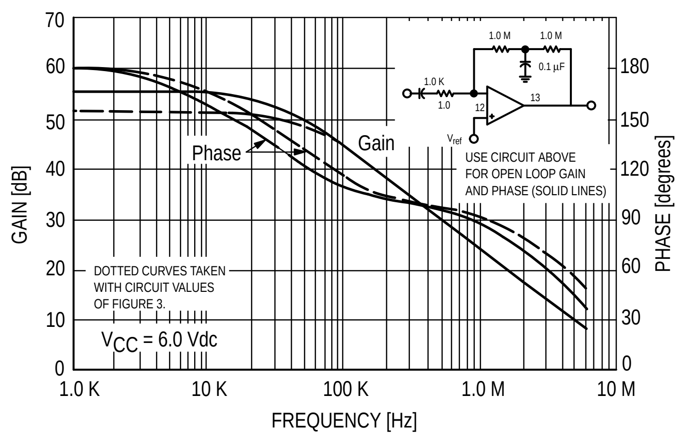


Figure 14. L/C Oscillator Recommended Component Values

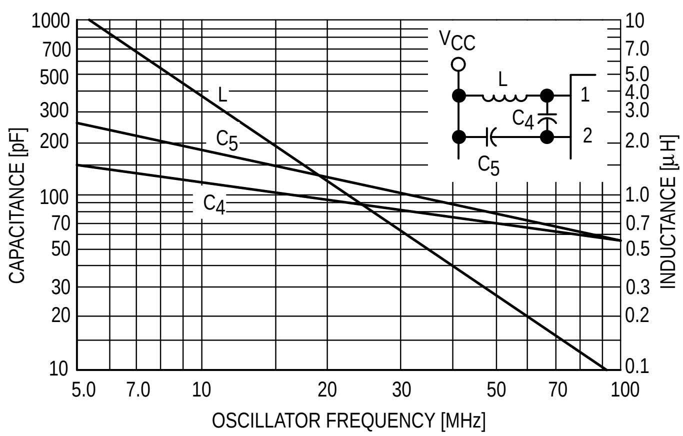
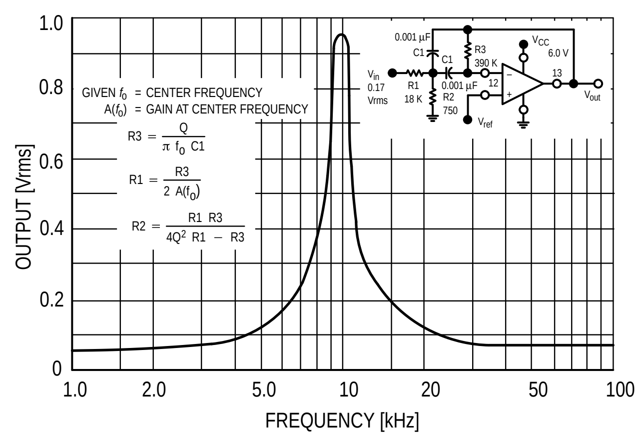


Figure 15. The Op Amp as a Bandpass Filter



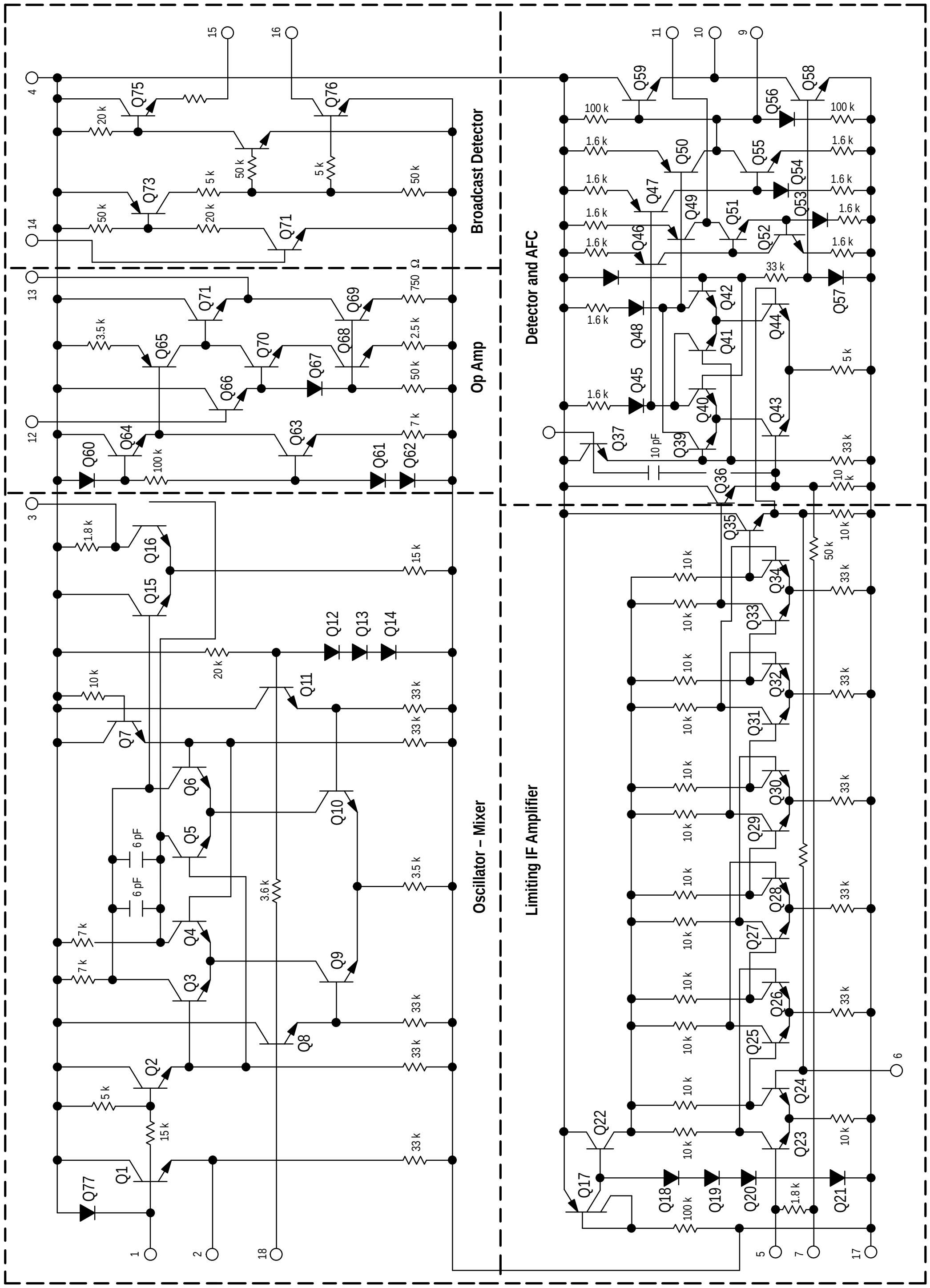


Figure 16. Representative Schematic Diagram

CIRCUIT DESCRIPTION

The MC3359 is a low–power FM IF circuit designed primarily for use in voice–communication scanning receivers. It is also finding a place in narrowband data links.

In the typical application (Figure 1), the mixer–oscillator combination converts the input frequency (10.7 MHz) down to 455 kHz, where, after external bandpass filtering, most of the amplification is done. The audio is recovered using a conventional quadrature FM detector. The absence of an input signal is indicated by the presence of noise above the desired audio frequencies. This “noise band” is monitored by an active filter and a detector. A squelch–trigger circuit indicates the presence of noise (or a tone) by an output which can be used to control scanning. At the same time, an internal switch is operated which can be used to mute the audio.

APPLICATIONS INFORMATION

The oscillator is an internally biased Colpitts type with the collector, base, and emitter connections at Pin 4, 1 and 2, respectively. The crystal is used in fundamental mode, calibrated for parallel resonance at 32 pF load capacitance. In theory this means that the two capacitors in series should be 32 pF, but in fact much larger values do not significantly affect the oscillator frequency, and provide higher oscillator output.

The oscillator can also be used in the conventional L/C Colpitts configuration without loss of mixer conversion gain. This oscillator is, of course, much more sensitive to voltage and temperature as shown in Figure 12. Guidelines for choosing L and C values are given in Figure 14.

The mixer is doubly balanced to reduce spurious responses. The mixer measurements of Figure 4 and 6 were made using an external 50 Ω source and the internal 1.8 k at Pin 3. Voltage gain curves at several V_{CC} voltages are shown in Figure 4. The Third Order Intercept curves of Figure 6 are shown using the conventional dBm scales. Measured power gain (with the 50 Ω input) is approximately 18 dB but the useful gain is much higher because the mixer input impedance is over 3 kΩ. Most applications will use a 330 Ω 10.7 MHz crystal filter ahead of the mixer. For higher frequencies, the relative mixer gain is given in Figure 8.

Following the mixer, a ceramic bandpass filter is recommended. The 455 kHz types come in bandwidths from ± 2 kHz to ± 15 kHz and have input and output impedances of 1.5 k to 2.0 k. For this reason, the Pin 5 input to the 6 stage limiting IF has an internal 1.8 k resistor. The IF has a 3 dB limiting sensitivity of approximately 100 µV at Pin 5 and a useful frequency range of about 5 MHz as shown in Figure 5. The frequency limitation is due to the high resistance values in the IF, which were necessary to meet the low power requirement. The output of the limiter is internally connected to the quadrature detector, including the 10 pF quadrature capacitor. Only a parallel L/C is needed externally from Pin 8 to V_{CC}. A shunt resistance can be added to widen the peak separation of the quadrature detector.

The detector output is amplified and buffered to the audio output, Pin 10, which has an output impedance of approximately 300 Ω. Pin 9 provides a high impedance (50 k) point in the output amplifier for application of a filter or de–emphasis capacitor. Pin 11 is the AFC output, with high gain and high output impedance (1 M). If not needed, it should be grounded, or it can be connected to Pin 9 to double the recovered audio. The detector and AFC responses are shown in Figure 7.

Overall performance of the MC3359 from mixer input to audio output is shown in Figure 9 and 10. The MC3359 can also be operated in “single conversion” equipment; i.e., the mixer can be used as a 455 kHz amplifier. The oscillator is disabled by connecting Pin 1 to Pin 2. In this mode, the overall performance is identical to the 10.7 MHz results of Figure 9.

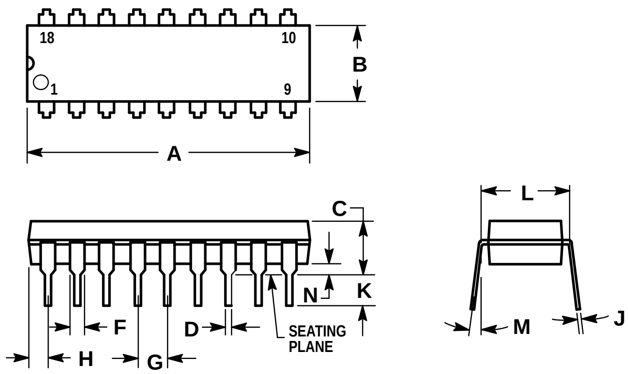
A simple inverting op amp is provided with an output at Pin 13 providing dc bias (externally) to the input at Pin 12, which is referred internally to 2.0 V. A filter can be made with external impedance elements to discriminate between frequencies. With an external AM detector, the filtered audio signal can be checked for the presence of either noise above the normal audio, or a tone signal.

The open loop response of this op amp is given in Figure13. Bandpass filter design information is provided in Figure 15.

A low bias to Pin 14 sets up the squelch–trigger circuit so that Pin 15 is high, a source of at least 2.0 mA, and the audio mute (Pin 16) is open–circuit. If Pin 14 is raised to 0.7 V by the noise or tone detector, Pin 15 becomes open circuit and Pin 16 is internally short circuited to ground. There is no hysteresis. Audio muting is accomplished by connecting Pin 16 to a high–impedance ground–reference point in the audio path between Pin 10 and the audio amplifier. No dc voltage is needed, in fact it is not desirable because audio “thump” would result during the muting function. Signal swing greater than 0.7 V below ground on Pin 16 should be avoided.

OUTLINE DIMENSIONS

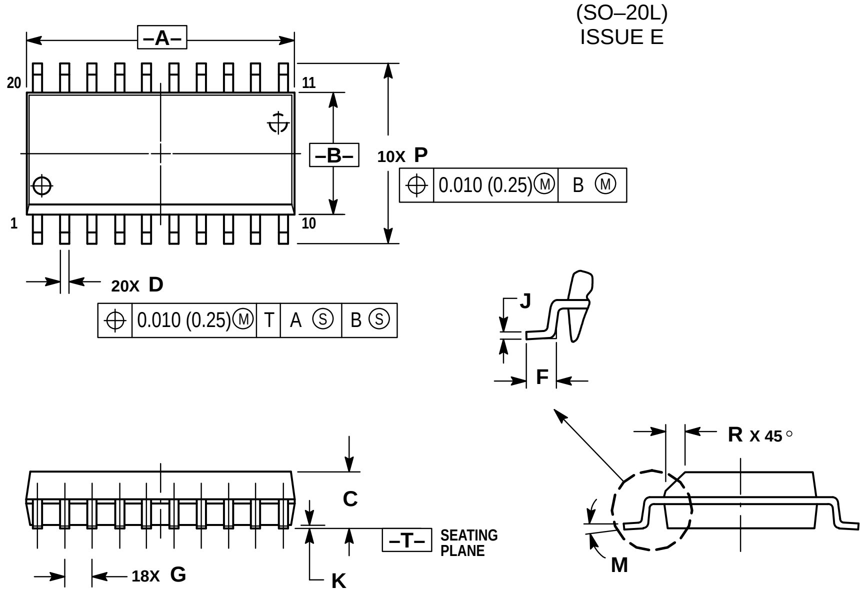
P SUFFIX
PLASTIC PACKAGE
CASE 707–02
ISSUE C



NOTES:
1. POSITIONAL TOLERANCE OF LEADS (D), SHALL BE WITHIN 0.25 (0.010) AT MAXIMUM MATERIAL CONDITION, IN RELATION TO SEATING PLANE AND EACH OTHER.
2. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION B DOES NOT INCLUDE MOLD FLASH.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	22.22	23.24	0.875	0.915
B	6.10	6.60	0.240	0.260
C	3.56	4.57	0.140	0.180
D	0.36	0.56	0.014	0.022
F	1.27	1.78	0.050	0.070
G	2.54 BSC		0.100 BSC	
H	1.02	1.52	0.040	0.060
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	15°	0°	15°
N	0.51	1.02	0.020	0.040

DW SUFFIX
PLASTIC PACKAGE
CASE 751D–04
(SO–20L)
ISSUE E



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.150 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.13 (0.005) TOTAL IN EXCESS OF D DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	12.65	12.95	0.499	0.510
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.50	0.90	0.020	0.035
G	1.27 BSC		0.050 BSC	
J	0.25	0.32	0.010	0.012
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	10.05	10.55	0.395	0.415
R	0.25	0.75	0.010	0.029

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